Appendix A 4 House scheme: technical note

YORK'S GREAT ENERGY EXPERIMENT

TECHNICAL NOTE ON THE 4 HOUSE SCHEME

1.0 INTRODUCTION

1.1 This scheme is part of a new initiative in York to improve the energy efficiency of its housing stock in order to provide affordable warmth for tenants and improve the environment. The project aims to demonstrate ways in which energy can be saved and carbon dioxide (CO_2) emissions reduced through the modernisation of existing local authority housing. The project is funded by the Department of the Environment as part of the Greenhouse Programme which provided some £10M in 1991/92 and has allocated £50M in 1992/93 for energy demonstration schemes. As the flagship scheme for the Yorkshire and Humberside region, the City of York received £196,000 in 1991/92 and has been allocated around £1.33M for 1992/93. It is expected that over the two years of the scheme about 430 homes in York will benefit from energy improvements. The lessons learned during the schemes will be applied to York's future modernisation programmes.

1.2 Two schemes have been completed in 1991/92;

1. **The 4 House Scheme** involves insulation improvements to a standard between 20% and 30% higher than current building regulations and explores 4 different heating strategies, two using gas and two electricity. The houses in this scheme will form the spearhead of the demonstration activity when they are open to the public and professional interest groups from 11th to 16th. April 1992.

2. **The 30 House Scheme** involves the improvement of 30 houses taken from York's 1991/92 modernisation programme and in addition to the usual modernisation works received insulation and heating improvements to a standard comparable with modern housing.

The impact of the improvements in both schemes will be monitored over the next 12 months and will be compared with the performance of a control group of 20 houses modernised in 1991/92 but without the additional energy conservation measures.

1.3 This technical note gives details and estimates of energy savings for the 4 House Scheme and is intended primarily as a guide to those professional and other special interest groups visiting the scheme.

1.4 Two Houses are in the Chapelfields area on the western edge of York and two in the Bell Farm estate to the north east.

2.0 BASIS OF ENERGY CALCULATIONS

2.1 The energy characteristics of each house were calculated using the National Home Energy Rating programs produced by the National Energy Foundation. The programmes are based on the Building Research Establishment's domestic energy

model (BREDEM). Since energy consumption varies considerably depending on patterns of use with in a house the calculations are based on a standard use pattern assuming occupation by 2 adults and 2 children, a heating period of 9 hours per day and a main living room temperature of 21 degrees celsius.

2.2 The NHER programs provide the following assessments:

1. An estimate of energy consumed broken down by areas of energy use (space heating, water heating etc.) and by fuel type.

2. An estimate of annual fuel costs.

3. A measure of the performance of the building fabric, its insulation and ventilation characteristics. This is done by the use of the Building Energy Performance Index (BEPI). The current building regulations standard approximates to an index of 100. The index in the completed houses ranged from 119 in Chapelfields to 130 in the Bell Farm houses.

4. An NHER energy label designed to rate the house against a scale of 0 to 10. The lower the score the less energy efficient the house and the more costly it is to run. The houses in the 4 house scheme had a before rating of around 2.5 and completed ratings of between 8.3 and 7.1. A typical range for new housing is between 5.0 and 7.5.

3.0 BASIS OF INSTALLATION COST CALCULATIONS

3.1 The cost of energy works are calculated net of costs related to general improvement or repair. Thus for example the extra cost of double glazing has been included but not the cost of replacing rotten or poor quality window frames.

3.2 The costs include the following:

- loft insulation
- cavity wall insulation
- additional cost of low emissivity double glazing
- additional cost of draught sealed and insulated loft hatch
- cost of draught sealing to suspended ground floors (Bell Farm houses)
- full cost of installing heating systems

3.3 In addition to energy monitoring an analysis of a wide range of buildability and costing issues will be carried out to establish not only net costs but also other areas of cost which an energy programme is likely to uncover. In particular the need for cavity wall repairs and possible wall-tie replacement prior to cavity filling.

4.0 THE CHAPELFIELDS HOUSES

4.1 The Demonstration Objectives:

i) **Chapelfields A**

To demonstrate significant energy and CO_2 emission savings through insulation and a gas central heating system based on the improved efficiency provided by a condensing boiler. Seasonal efficiency improvements of approaching 20%

are expected.

ii) **Chapelfields B**
To produce an energy efficient home which can provide the required comfort levels but at a lower capital cost than that of a full central heating system. With good insulation (particularly in a small house) a full central heating system is not necessary to provide whole house heating.

4.2 **The houses prior to improvement.**

House type:- two bedroom, semidetached constructed in the 1950s.

Construction:- load-bearing cavity brick work with a pitched tile roof and solid concrete ground floor (U value 0.73 no measures applied). Plan area 34.8m^2

Condition:- No modernisation works since construction. Rewired and repaired only.

Existing Insulation:- 100mm loft insulation fitted within the last 5 years.

Heating and Hot Water:- gas fire in the lounge/dining room and hot water provided by an immersion heater fitted to a lagged cylinder.

4.3 **The Energy Improvements**

4.3.1 **Improvements to the construction**

1. Top up existing loft insulation to 200mm. (U Value - 0.22)

2. Cavity wall insulation using blown fibre (60-65mm cavities U Value - 0.48)

3. Replace windows and doors with draught sealed frames fitted with 20mm low emissivity double glazing units (Pilkington K Glass). (Low emissivity glazed units achieve a similar level of insulation to standard triple glazing U value - 1.9)

4. Provide insulated and draught-sealed loft hatch.

The draught sealing of windows and doors and the loft hatch is expected to increase the air-tightness of the houses to give 7 air changes per hour at 50Pa. This level approximates to a seasonal average ventilation rate of 0.35 ac/h. The extent to which the required target is reached will be verified by air pressure tests during monitoring.

4.3.2 **Improvements to Heating and Hot Water Systems**

Chapelfields A

1. Gas wet central heating system with a Glow-worm Energysaver 30 condensing boiler with an output of 8.8kW).

2. High recovery hot water cylinder with 50mm. spray foam insulation (IMI supercal cylinder; 117 litre capacity).

3. Temperature control is provided by a room thermostat (space heating) and, cylinder thermostat (hot water). A single programmer provides time switching for the system.

4. All primary heating pipe work and hot water service pipes are insulated.

Chapelfields B

1. Gas room heaters designed to give whole house heating.

2. Hot water is provided by an instantaneous (multipoint) gas water heater.

3. Temperature control is provided by individual heater thermostat A single programmer provides time switching for the system.

4. All hot water service pipes are insulated

5.0 Energy and Environmental Information

5.1 The improvements are expected to result in significant reductions in the energy consumed and in CO_2 emissions. The following tables show estimated energy costs and CO_2 for each house on a before and after basis. The total cost of achieving the energy savings is also given and an overall payback period calculated. The basis of the calculations is given in sections 2 and 3 above.

5.2 Chapelfields A

Total cost of insulation and heating improvements - £3310
Total annual running cost saving - £448
Payback period - 7.4 Years

Item	Before	After	Saving (Percentage)
Heating	£321	£97	£224 (70%)
Hot water	£295	£71	£224 (76%)
Lights, cooking, appliances and standing charges	£280	£280	£0
Total Energy Costs	£896	£448	£448 (50%)
Total Energy Consumption (Gj/Year)	101.6	51	50.6 (50%)
Carbon Dioxide	8.4 tonnes/yr	3.8 tonnes/yr	4.6 tonnes/yr (55%)
Building Energy Performance Index (BEPI)	59	119	+60
National Home Energy Rating (NHER)	2.6*	8.3	+5.7

* Uncertified rating

Table 5.1: Energy and Environmental Summary (Chapelfields A)

5.3 Chapelfields B

Total cost of insulation and heating improvements - £2530
Total annual running cost saving - £446
Payback period - 5.7 Years

Item	Before	After	Saving (Percentage)
Heating	£321	£98	£223 (69%)
Hot water	£295	£72	£223 (76%)
Lights, cooking, appliances and standing charges	£280	£280	£0
Total Energy Costs	£896	£450	£446 (50%)
Total Energy Consumption (Gj/year)	101.6	53.3	48.3 (48%)
Carbon Dioxide	8.4 tonnes/yr	3.8 tonnes/yr	4.6 tonnes/yr (55%)
Building Energy Performance Index (BEPI)	59	119	+60
National Home Energy Rating (NHER)	2.6*	8.3	+5.7

* Uncertified rating

Table 5.2: Energy and Environmental Summary (Chapelfields B)

6.0 THE BELL FARM HOUSES

6.1 The Demonstration Objectives:

i) **Byland Avenue A**
To demonstrate significant energy and CO_2 emission savings through insulation and an electric central heating system based on an electric boiler. Hot water is provided by an economy 7 cylinder with improved insulation. Mechanical ventilation with heat recovery is also being demonstrated

ii) **Byland Avenue B**
To demonstrate the use of heat pump technology at a domestic scale in order to achieve greater reductions in CO_2 than with more conventional electric heating systems.

6.2 The houses prior to improvement.

House type:- three bedroom, semidetached constructed in the 1930s.

Construction:- load-bearing cavity brick work with a pitched tile roof. Ground floor construction - part solid (U value 0.73) and part suspended timber (U value .38) Plan area 37.5m²

Condition:- Some modernisation works in early 70s but in need of renewal. Rewired and repaired including roof renewal.

Existing Insulation:- 25mm loft insulation fitted in early 70s. (roof U value 1.07)

Heating and Hot Water:- Old style electric storage heaters and electric fire in the lounge. Hot water old style economy 7 immersion heater cylinder with mineral fibre lagging.

6.3 The Energy Improvements

6.3.1 Improvements to the construction

1. Top up existing loft insulation to 200mm. (U Value - 0.22)

2. Cavity wall insulation using CFC free polyurethane foam (60-65mm cavities U Value - 0.38)

3. Replace windows and doors with draught sealed frames fitted with 20mm low emissivity double glazing units (Pilkington K Glass). (Low emissivity glazed units achieve a similar level of insulation to standard triple glazing U value - 1.9)

4. Provide insulated and draught-sealed loft hatch.

Polyurethane foam is used in this case in order to establish its effectiveness in improving the air-tightness of the house. It is important in these houses to ensure that as much ventilation as possible passes through the heat recovery systems. When combined with the other air-tightness measures an air infiltration rate of 5 ac/h at 50Pa is expected. This level approximates to a seasonal average infiltration rate of 0.25 ac/h. Early pressure tests confirm that a rate of 5 ac/h @50Pa. or better is likely to be achieved. Further tests will be performed during the monitoring phase.

6.3.2 Improvements to Heating and Hot Water Systems

Byland Avenue A

1. Electric wet central heating system with a GEC drycore electric boiler with a rating of 45kWhs. The system operates on the Northern Electric variable tariff structure (Super Tariff).

2. Mechanical ventilation system with heat recovery (ADM indux system expected efficiency of 65% to 70%)

3. Control is provided by a thermostat\programmer located in the lounge. Radiators are fitted with TRVs.

4. All primary heating pipe work and hot water service pipes are insulated.

5. Hot Water is provided by an Economy 7 cylinder with 75mm. of sprayed foam insulation.

Byland Avenue B

1. Mechanical ventilation system with air-to-air heat pump and heat exchanger. Two 500W resistance duct heaters provide top up heating together with a focal point fire.

2. Temperature control is provided by three stage thermostat set to operate heat pump and duct heaters in sequence so as to maximise the use of the heat pump.

3. Hot water is provided by an Economy 7 cylinder with 75mm. of sprayed foam insulation.

7.0 Energy and Environmental Information

7.1 The improvements are expected to result in significant reductions in the energy consumed and therefore fuel bills and CO_2 emissions. The following tables show the estimated energy costs and CO_2 emissions for each house on a before and after basis. The total cost of achieving the energy savings is also given and an overall payback period calculated. The basis of the calculations is given in sections 2 and 3 above. Costing assumptions in the case of Byland Avenue A and B are based on blown fibre cavity insulation and not polyurethane foam. This is because the use of foam is experimental and since it is much more expensive than blown fibre and would distort payback figures. NHER and BEPI however are based on the actual insulation used.

7.2 Byland Avenue A

Total cost of insulation and heating improvements - £3800
Total annual running cost saving - £528
Payback period - 7.2 Years

Item	Before	After	Saving (Percentage)
Heating	£635	£143	£492 (77%)
Hot water	£129	£93	£36 (28%)
Lights, cooking, appliances and standing charges	£283	£283	£0
Total Energy Cost	£1047	£519	£528 (50%)
Total Energy Consumption (Gj/Year)	89.3	43.3	46 (52%)
Carbon Dioxide	17.5 tonnes/yr	7.4 tonnes/yr	10.1 tonnes/yr (58%)
Building Energy Performance Index (BEPI)	57	130	+73
National Home Energy Rating (NHER)	2.4*	7.1	+4.7

* Uncertified rating

Table 7.1: Energy and Environmental Summary (Byland Avenue A)

7.3 **Byland Avenue B**

Total cost of insulation and heating improvements - £3805
Total annual running cost saving - £476
Payback period - 8 Years

The figures for running costs are much more tentative in this case than in the other houses. This is because the heat pump unit is not fully taken in to account by the NHER programs. Figures should therefore be treated with more caution.

Item	Before	After	Saving (Percentage)
Heating	£635	£195	£440 (69%)
Hot water	£129	£93	£36 (28%)
Lights, cooking, appliances and standing charges	£283	£283	£0
Total Energy Cost	£1047	£571	£476 (45%)
Total Energy Consumption (Gj/year)	89.3	35.6	53.7 (60%)
Carbon Dioxide	17.5 tonnes/yr	5.3 tonnes/yr	12.2 tonnes/yr (70%)
Building Energy Performance Index (BEPI)	57	130	+73
National Home Energy Rating (NHER)	-	-	-

Table 7.2: Energy and Environmental Summary

8.0 MONITORING

8.1 In each of the 4 houses intensive monitoring will take place to establish the performance of the different systems in terms of heat flows with in the systems and the internal temperatures achieved. Of particular interest in the heat pump house for example will be the on-peak/off-peak split on electric consumption for space heating and the ratio of heat pump to resistance heating.

8.2 A more limited monitoring operation will take place on the 30 house scheme where internal temperatures will be related to energy consumption and compared with similar houses which have been improved but without the energy conservation measures.

Note prepared by:
Malcolm Bell (York Reader in Housing, Leeds Polytechnic)
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